to take a series of pictures, showing the step of "Occident" at all its stages, and in this manner, for the first time, the precise difference in the motions of different horses can be clearly represented—a matter of much interest to horsemen, for trotters vary in their action, one having his fore-leg straight when it touches the ground, another crooked, and so on.—*San Francisco Post.*

PLATE-IN-THE-BATH PICTURES.

By FRED. SCOTT ARCHER.

THE bath is about three parts filled with a solution of nitrate of silver of the usual strength, and the prepared glass (as soon as the film of the collodion has set) is plunged into it. The whole is then placed in its proper position in the camera—the focus having been previously obtained, and the light is thus allowed to act on the prepared film, whilst in the bath of nitrate of silver. By this means, great cleanliness is preserved in the manipulations, and very delicate pictures are obtained. I have used this bath during the whole of the summer and autumn, and several friends, at my suggestion, have adopted it with great success. The bath is made in two pieces of the best plate glass, connected toge her at the sides and bottom, and gradually tapering downwards, so as to form a narrow wedge-shaped bath; the top being about three-eighths of an inch wide, and the bottom one eighth. This bath is cemented into a wooden frame, having a closely fitting lid to prevent all dust falling into the solution.

MEASUREMENT OF HEIGHT OF CLOUDS.

By A. MALLOCK.*

IF the clouds remained practically stationary for any time, and with their contours unaltered, there would be no difficulty in measuring their height, for if such were the case the observers might agree to measure the altitude and position of some prominent feature in a cloud at the ends of a measured base, which would, of course, give the necessary data; but in general the clouds not only move too fast for this to be done, but their contours, partly from the effect of perspective and partly from other alterations, change rapidly also, so that what perhaps was at one moment a well-marked feature may in five minutes become unrecognizable.

The observations, then, by which the heights of clouds are to be measured, must first of all be simultaneous, and they ought to be made on as many points as possible to obviate the unavoidable uncertainty as to the actual identity of the points observed at each station.

To secure these objects I had recourse to photography, and the way in which the photographs were taken and analyzed I will now describe. A pair of cameras, of one of which Fig. 1 is a section, were placed one at each end of a measured base-line, and the lenses pointed to the zenith by means of the leveling screws A A.

The dark slide (B) fits as a drawer below, and consists of a shallow box, the lid being opened after it is placed in position by means of the milled head (C). Simultaneous exposure of the sensitive plates is insured by uncovering the lens by an electric magnet apparatus (E), both cameras being in one circuit.

After a photograph is taken it is necessary to know the exact position which the plate occupied with reference to the lens; and as it would be impossible—or, at least, very inconvenient—to be obliged to have all the plates and fittings of the slide made with sufficient accuracy to obtain this knowledge, I have made use of an easier, and, at the same time, a more efficient plan.

H is a horizontal axis, fixed in one side of the camera, movable from the outside by the milled head (K). On this axis, in the same plane, and terminated in sharp points, are two arms (L), which, in their ordinary position, lie back flat and upright against the side of the camera; but after the photograph has been taken, and before the dark slide has been touched, the head (K) is turned so that points descend on the plate and puncture the film in two places. As the axis (H) is fixed in the camera, and, therefore, fixed as regards the lens, the two punctures left on the film leave a trustworthy record of the position of the plate at the time of exposure.

The constants, which must be known for each camera before the photographs can be analyzed, are:

1. f, the distance of the optical center of the lens from

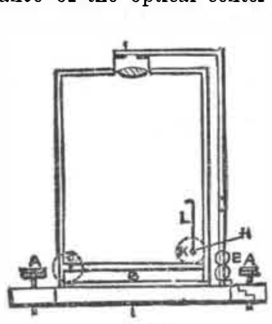


Fig. 1.

the plate. 2. The co-ordinates, x' and y', of that point in the plate which corresponds to the zenith, the axis of x passing through to the points marked on the film, one of them being the origin.

To obtain these co-ordinates I photograph a target (Fig. 2) placed in the zenith at such a distance from the camera that a well-defined picture may be taken without altering the adjustment of the lens. A plumb-line passes through the center of the target, and the camera is placed in position by its means. x' and y' (Fig. 3) are then the co-ordinates of the center of the target in the photograph. I may here remark that any small difference between the optical and geometrical center of the lens, such as is often found to exist, will produce errors of the second order only in the result. A comparison of the actual size of the target with that of the photograph will, of course, give f, but for greater certainty I measured f also by taking another photograph with the camera displaced horizontally by a known amount from its first position immediately under the target.

Having got these constants, the analysis of any pair of photographs is very easy. What has to be found is the tangent of the parallax which the cloud would have if it were immediately over one of the cameras, which may be expressed in this case as the difference of the projections on the line joining the two cameras of the distance of corresponding points in the photographs. [The author then described the trigonometrical method of calculating the parallax, and finally showed that $h = p. l.$, whence h = height of the cloud, l = length of the base, $p = \frac{d}{f}$, d being the difference of the measured points in the photographic paper, and f the focal length of the lens.]

It will be noticed that it is not the distance of the cloud from the camera, but its perpendicular distance from the earth, and this due to the fact of the plate being horizontal, that is concentric with the surface of the earth. What is really measured is the distance of the cloud from the plane of the plate, so that had any other direction than the vertical been given to the camera—which, of course, might be done—another factor, the same nearly of the angle of elevation of the camera, would appear in the result. There are several

advantages, however, in placing the cameras vertically, among which may be mentioned that it is always easy, by means of levels, to ensure a known line in each instrument being vertical; whereas to ensure parallelism in the direction of the camera in any other case requires an adjustment in azimuth, which becomes more and more important as the direction chosen deviates further from the vertical. The disadvantage of placing the cameras vertical is that very often the clouds which it may be required to photograph do not show in the field.

With regard to the practical part of the analysis, I find that the quickest and most convenient way of finding d is to place the negatives side by side in a frame fitted with a reflector, and with a fine needle to mark a number of corresponding points in each picture; the co-ordinates of these points are then measured by a micrometer, and the points so found, together with the zenith points, are plotted on tracing an enlarged scale, one set of measures being plotted on tracing paper. The tracing is then applied to the other drawing, so that the corresponding points in each may fit as well as possible. The distance between the zenith point in the tracing and drawing $= d$, and the line through them is the

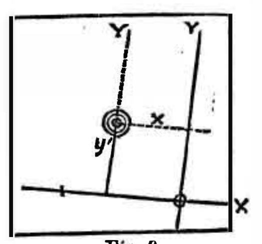


Fig. 3

direction of the line joining the two cameras. I find it quicker to arrive at the direction of the base-line by drawing than by calculation, while at the same time the drawings give greater facility for distributing the errors advantageously. As to the length of the base-line to be employed, I should say that the shorter it is in reason the better. That which I used was about two hundred yards. Undoubtedly the shorter it is the more convenient, and also, as clouds are often very thick, their contours may, if the base be long, be so different, according as to whether they are seen from one end or the other, as to make the photograph practically useless.

The results obtained are, I have reason to believe, accurate within five per cent, which is quite near enough for all practical purposes. This refers principally to measures of high clouds. Rain clouds were found as high as 4,000 feet. Cumulus was seldom lower than 6,000 or more than 8,000 feet; cirro-cumulus up to 20,000, and cirrus to 28,000 and 80,000 feet. Isolated measures like these cannot, of course, lead to much; but if this method was used systematically at observations, much interesting information might, no doubt, be obtained about the formation of cirrus clouds, and also about the winds in the higher strata of the atmosphere.

* Read before the Briti h Association.

NEW MICROSCOPIC ATTACHMENT.*

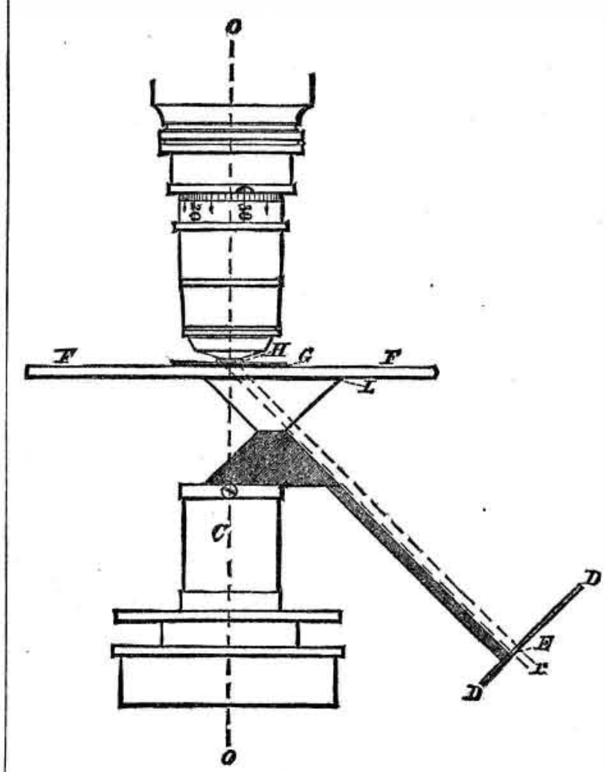
A Simple Device for the Illumination of Balsam-mounted Objects for Examination with certain Immersion Objectives whose "Balsam Angle" is 90° or upwards.

By Surgeon J. J. WOODWARD, Brevet Lieut.-Col., U. S. A.

CERTAIN immersion objectives are so constructed that they are capable of admitting rays which enter the front lens at a greater angle with the optical axis than the limit for dry objectives. That this is not only theoretically possible, but that such objectives have been successfully constructed, was several years since demonstrated, in the *Monthly Microscopical Journal*, both by Mr. Keith and myself,† notwithstanding which, the contrary has often since been energetically asserted by writers in the same journal.

Meanwhile, immersion lenses possessed of the excessive angle in dispute continue to be put into the market by more than one maker; and perhaps some of the purchasers will be interested in a simple device which I have used for some time with such objectives to illuminate test-objects mounted on balsam. The device consists merely of a right-angled prism of crown glass mounted beneath the stage in such a manner that its long side can be connected, by oil of cloves or some similar fluid, with the slide on which the object is mounted. The details of the plan will be understood from the diagram annexed, in which the glass prism is seen in section just beneath the object-slide F F. Just below it is another right-angled prism, of the same dimensions, made of brass; the section of this prism is indicated by dark shading in the diagram. The right angles of both prisms are truncated, and the facets are cemented together in such a manner that the long sides of the prisms are parallel. The brass prism slips transversely in a groove in the top of a holder, C, which is fitted into the sub-stage of the microscope. D D is a blackened brass screen held in position by two brass arms, one of which is shown in the figure. This screen is parallel to the adjacent face of the glass prism, and has in it a small circular aperture, E, about the size of a large pin-hole. The side of the glass prism next the screen is covered with black paper in which is a corresponding pin-hole. The two pin-holes are so placed that a beam of parallel white sunlight (r) passing through both will be perpendicular to the side of the glass prism on which it impinges.

To use this apparatus it is adjusted in the sub-stage of the microscope, a drop of oil of cloves is placed on the upper face of the prism, the glass slide F F, on which the object is



mounted in Canada balsam under the usual thin cover, G, is placed on the stage, and the sub-stage is racked up until the drop of oil of cloves is spread out into a thin layer, I.

The object being thus arranged, it is evident that if a beam of parallel solar rays (white sunlight), reflected from a plane mirror, be thrown through the two apertures upon the face of the prism, being perpendicular to that face, it will enter and pass through without refraction until it reaches the upper surface of the thin glass cover G. The parallel rays impinge upon this surface, as is evident from the construction, at an angle of 45° with the optical axis O O. If, now, the medium next above the thin cover, G, be air, this obliquity will be greater than the critical angle, and total reflection of the rays will take place. If, however, the medium next above the thin cover be water, the obliquity will *not* be greater than the critical angle. Refraction having taken place, the rays will enter the water, H; and if an immersion lens of sufficient angle of aperture be focussed upon the objects mounted beneath the cover G, these rays not merely enter the front of the objective, but will form a well-defined image of the object on a brightly illuminated field, which will be visible through the eye-piece of the instrument in the usual way. Of course it is evident from the diagram that with no dry objective, or any immersion objective of less than 90° balsam angle, can anything whatever of balsam-mounted objects* thus illuminated be seen.

Immersion objectives may be divided according to their behavior with this apparatus, into three classes: 1st. Those with which, since they do not have sufficient angle of aperture to admit the illuminating pencil, nothing can be seen, precisely as in the case of dry objectives. 2d. Those which have sufficient angle of aperture to admit rays of this obliquity, but are incapable of bringing them to an image-forming focus; with these the field appears well illuminated, but the objects are not well defined. 3d. Those which not only admit rays of this obliquity, but form well-defined images with them. To this class belong not merely immersion objectives with the so-called duplex fronts, but others; and I may add, not merely objectives of American make, but some constructed by a well-known English house. As might be expected, the quality of the image formed by the direct rays of the sun thrown through a pin-hole at this excessive obliquity varies very greatly in different cases. I will state, however, that I have thus far found at least seven objectives, some of English, others of American make, which define sufficiently well under these circumstances to resolve *amphipleura pellucida* mounted in Canadian balsam. With the objectives which performed best, the field was of exceeding whiteness and brilliancy, but by no means dazzling, the frustule undistorted, and the striæ clean and black on the white ground, very little color-aberration being perceived. With other objectives there was more or less color-aberration and distortion, both which faults were in one or two cases very conspicuous, although, in the part of the frustule most sharply focussed upon, the striæ were handsomely brought out. The objectives with which I thus succeeded, ranged all the way from a ¼ to $\frac{1}{16}$ immersion. I will add that the objectives which resolved *amphipleura pellucida* under these trying circumstances, when used in the ordinary way with this or other test-objects, displayed an exquisite perfection of definition which it would be hopeless to expect to attain with objectives of less angular aperture.

As it is no part of my purpose in this communication to provoke ill-tempered discussion of the merits of individual makers, I will not append a list of the results obtained with the various immersion objectives I have tried in this

* A paper read before the Royal Microscopical Society, June 6, 1877.

† June, 1873, p. 268; November, 1873, p. 210; March, 1874, p. 119; September, 1874, p. 124.

* The apparatus can be used, of course, to secure black-ground illumination of suitable dry objects if they are mounted on the slide instead of the cover, as is usual.